The Commonwealth of Massachusetts
Executive Office of Public Safety
Department of Fire Services
P.O. Box 1025 ~ State Road
Stow, Massachusetts 01775
(978) 567~3100 Fax: (978) 567~3121

DEVAL L. PATRICK
GOVERNOR

TIMOTHY P. MURRAY
LT. GOVERNOR

KEVIN M. BURKE
SECRETARY

STEPHEN D. COAN
STATE FIRE MARSHAL

THOMAS P. LEONARD
DEPUTY STATE FIRE MARSHAL

Summary of Arnel/CAI Danvers Explosion Investigation Findings

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THE EVENT

On Wednesday, November 22, 2006 at approximately 2:46 A.M., the Danvers Fire Department received a master firebox alarm coming from the property located at 128 Rear Water Street, Danvers, Massachusetts. As fire department personnel began to respond, they heard a large explosion and saw heavy fire conditions in the area of 128 Rear Water Street. On their way to the fire scene, Danvers firefighters observed that homes and businesses along Water Street had been obviously impacted by the explosion and noticed that the closer they got to the fire scene, the greater the damage to buildings.

Ultimately, over thirty area cities and towns responded to the incident to offer aid to the Town of Danvers and assist injured residents. Approximately twenty area residents were transported to the Beverly Hospital, Salem Hospital or Lahey Clinic/North for various injuries and illness related to the blast. Given the large number of homes and business impacted by the explosion, it is remarkable that no one died.

Initial reports, received from various sources, indicated that pressure waves from the explosion were felt approximately 25 miles away. Pieces of building debris were recovered approximately ¼ of a mile away from the building, with pressure damage impacting buildings as far away as 2¼ miles from 128 Rear Water Street.

As of May 1, 2007, approximately 250 residences, 20 businesses and one school (located in Danvers, Beverly, Peabody and Salem, MA) were damaged as a result of this explosion. Of the 250 homes, 80 were temporarily ordered to be evacuated, immediately following this incident. To date, 16 homes and 6 businesses have been ordered to be demolished either by public officials or by the owner's insurer, because they were either structurally unsound or economically beyond repair. In total, over 300 commercial and passenger vehicles as well as 65 boats were damaged or destroyed as a result of the explosion and subsequent airborne debris.

THE INVESTIGATION

The investigation was conducted by the Department of Fire Services, which includes State Police Investigators assigned to the State Fire Marshal, the Danvers Fire Department, the Danvers Police Department and the federal Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF).

Additionally, representatives from the Essex County District Attorney's Office, Massachusetts Department of Environmental Protection (DEP), the Massachusetts Environmental Police (MEP), the Massachusetts Department of Public Safety, the U.S. Environmental Protection Agency (EPA), the Occupational, Safety and Health Agency (OSHA), and the United States Coast Guard (USCG) also participated. Support services were provided by the Department of Fire Services Hazardous Materials Emergency Response division, federal Urban Search and Rescue Region I Team (USAR), and the American Red Cross.

In the earliest stages of the investigation, investigators were able to determine that there was no evidence of criminal conduct and quickly shifted their focus to an accidental cause investigation. Great care was taken by investigators during their on-scene investigative phase so as to preserve the building with minimal disturbance to allow for a subsequent and thorough investigation by other interested parties.

As the investigation proceeded, investigators systematically eliminated potential outside sources of the explosion such as natural or methane gas. The internal scene examination likewise, systematically eliminated several theories leading investigators to focus on the processing or production areas of the building. Through witness interviews, forensic scene examination and scientific laboratory testing of samples taken at the scene, investigators were able to determine that the likely cause of the blast was due to a high order chemical vapor explosion.

POSSIBLE IGNITION SCENARIOS

As previously mentioned, several initial theories regarding the potential fuel source were considered and eliminated. These included:

Natural Gas

Natural gas was eliminated as a possible cause of the explosion. There was no natural gas service to the building where the explosion originated. Investigators concluded that if there had been a natural gas leak in the neighborhood, it would have had to bypass a significant number of other ignition sources prior to entering this building. There was no indication that natural gas had communicated into 128 Rear Water Street via sewer lines or other potential pathways. In addition, at no time did residents or business employers in the area, report smelling any odor associated with natural gas. The only work order for natural gas in the area had occurred three weeks earlier and was approximately 1½ miles away from the site of the explosion.

In the days and weeks following the incident, during both the scene examination and during two months of daily EPA remediation, no readings of natural gas vapors were found in or around the building located at 128 Rear Water Street. Although Keyspan employees were on site, from the morning of the incident and for the next several days searching for any post-blast disruption to their natural gas lines, no leaks or pre-blast natural gas disorders were ever found.

Further, on March 9, 2007, investigators responded to 128 Rear Water Street on a report by residents and other interested individuals that natural gas was emanating from the slab floor of the building. With the assistance of a KeySpan employee, mobile and portable natural gas readers were deployed onto the building slab and in the surrounding area. No natural gas readings were detected. However, at that time, propane fuel tankers were being purged and filled at Eastern Propane located across Water Street. Investigators determined that the wind, which was blowing towards 128 Rear Water Street from the direction of Eastern Propane, was transmitting propane vapors into the neighborhood. Based on the observations of the investigators, they believe that an accumulation of natural gas was **NOT** the cause of the explosion at 128 Rear Water Street.

Methane Gas

Immediately after the explosion and in the ensuing days, various meters were used to record and identify hazardous materials in the air and in order to determine if other gaseous vapors were present. During the course of the EPA's remediation efforts at the scene, various levels of methane gas were identified. Methane gas is a naturally occurring gas given off as the result of decomposition, often found in swamplands, wetlands or marshy areas such as the area around 128 Rear Water Street. The level of methane gas found in the area was not sufficient to have caused the explosion. Therefore, methane gas was **NOT** the cause of the explosion at 128 Rear Water Street.

Furnaces

The furnaces located within 128 Rear Water Street were inspected by investigators and inspectors from the Department of Public Safety. The damage to these units was caused by external pressure and debris. No internal mechanical failures were noted. The physical examination of the furnaces within this building, indicate they did not fail and did **NOT** cause of the explosion at 128 Rear Water Street.

Dust Collection System

Two dust collection systems were in operation within this building. One unit was located in the courtyard of the building. The second collection unit was located along a wall of the building. Both collection units were external systems. Had combustion occurred within either of these units, the resulting explosions would most likely have been confined to the external areas of the building. The probability that the dust collection system played any role in the primary explosion at 128 Rear Water Street is highly unlikely. One again, the dust collection system was **NOT** the cause of the explosion at 128 Rear Water Street.

Fuel Farm

The "fuel farm" is a series of underground chemical storage tanks, which investigators eliminated as being involved in the ignition scenario. Following the blast, the EPA pumped a large volume of stored chemicals out of the underground storage tanks. Given the volume of chemicals left in these tanks after the explosion, it is not possible that there had been a leak or breach in these storage tanks prior to the blast.

Additionally, as all of the chemicals inside of these tanks were substantially heavier than air, had vapors from these tanks ignited, then more obvious and visible signs of that explosion would have been observed (i.e., heaving of the tanks, heaving of the ground, beveling of the foundation wall along near the tanks, etc.). Since there was no physical damage to the pipes running from the underground tanks to the building, investigators turned their attention away from this theory. Accordingly, the "fuel farm" was **NOT** the cause of the explosion.

THE MIXING VESSEL

The building at 128 Rear Water Street contains a processing area that is shared by the CAI and Arnel companies. CAI's ink producing process involves the heating of a mixture of chemicals in a large mixing vessel, to a certain temperature, shutting off the heat and then mixing the chemicals for a fixed period of time. Witness interviews have led investigators to conclude that one of the chemicals involved, (1,000 gallons) Heptane, was contained in vessel #4 and was most likely overheated due to a failure to turn off the steam heat system.

The characteristics of Heptane make the chemical a highly flammable and colorless solvent, commonly used in the production of inks. Because Heptane vapors are approximately 3.5 times heavier than air, they tend to sink to the lowest spot of a building and can collect over time.

Investigators formed the opinion that the greatest accumulation of chemical vapors were located in the manifold room and production area of the building, near the exterior ramp door near the Bates Street side of the structure.

Several samples were taken from different areas of the blast site for chemical analysis. These samples were taken from the areas of the greatest damage of the most interest to investigators. Of the 11 ground samples taken, 8 indicated the presence of Heptane.

FINDINGS

The most probable cause of the November 22, 2006 explosion at 128 Rear Water Street in Danvers, Massachusetts was a high order chemical vapor explosion of Heptane vapors caused by the inadvertent overheating of the chemical in mixing vessel # 4. The specific ignition source is undetermined. However, there were a number of potential ignition sources that existed in the building including: refrigerator motors and condensers, vending machine motors and condensers, space heaters, electrical exhaust fans, and the furnace.

Investigators believe that, in all probability, the accumulation of those Heptane vapors set the stage for any one of these ignition sources to have triggered the explosion. At that

unknown ignition source, the chain reaction chemical explosion was initiated and traveled back to the area where the greatest accumulation of chemical vapors had occurred. This then resulted in a high order explosion, detonation of those vapors, and complete destruction of the building.

RECOMMENDATIONS

As a result of prior chemical manufacturing process incidents, the Department of Fire Services had requested the state Board of Fire Prevention Regulations, (who oversee the promulgation of the state fire safety code) to review this important area. The Board subsequently, began to undertake a public safety review of safety issues surrounding chemical manufacturing.

Currently, the matter is assigned to a sub-committee of the Board, who will shortly report back their findings and recommendations to the full Board. The Department of Fire Services is committed to working and assisting the Board in the promulgation of effective fire/explosion safety regulations in this area to prevent future tragedies such as what occurred in Danvers from happening again.

Shortly, the Department of Fire Services and Department of Environmental Protection will announce a join inspection program to be conducted at chemical manufacturing process facilities.